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THESIS

THE HIGH POWER DEVICE TESTER ADDITION TO CASS: A LIFE CYCLE COST ANALYSIS

by

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June, 1994

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THE HIGH POWER DEVICE TESTER ADDITION TO CASS: A LIFE CYCLE COST ANALYSIS

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ABSTRACT

This thesis is a Life Cycle Cost (LCC) evaluation of the proposed acquisition of a High Power Device Tester (HPDT) to increase the capabilities of the Consolidated Automated Support System (CASS). It develops a LCC model for HPDT and the applicable existing ATE. The LCC model results are compared and evaluated for performance based on the Net Present Value of the annual and cumulative funding outlays. Its conclusions are that HPDT will be cost beneficial over the existing ATE and will lead to great savings in aviation support costs. These cost savings however, are vulnerable to technology growth induced obsolescence and program introduction decisions. Such decisions include delays in implementation which will cause continued support of the higher cost systems. Delays in off loading the existing ATE also affect the cost effectiveness of the HPDT and may result in costly support of both systems.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

Automatic test equipment (ATE) is a critical element in the maintenance and logistical support of Naval aircraft. It has become so critical that with virtually every new weapon system or component acquired, a new piece of specific ATE is required to help support it. Over the years the proliferation of ATE has developed into a logistical problem of its own. In an effort to create a standard and reverse the proliferation of ATE, the Navy has adopted the Consolidated Automated Support System (CASS). Although CASS has the capability to test *many components* with one test station, it still has design limitations that make testing high power components impossible. A High Power Device Tester (HPDT) is being planned as an addition to the CASS radar configuration in order to remedy the power shortfall.

1. CASS

The Consolidated Automated Support System (CASS) is a computerized Automatic Test Equipment (ATE) system now being fielded to improve the quality and reduce the costs of supporting electronic components at the factory, depot, and intermediate maintenance levels. In an effort to improve

support standardization, the Secretary of the Navy mandated CASS as the standard ATE system for Navy electronics. CASS will eventually replace most existing Navy ATE and support a wide range of emerging NAVAIR, NAVSEA, and SPAWAR weapons systems and potential joint service programs under the guidance of an Office of the Secretary of Defense steering group on automatic test systems standardization. [REF. 1]

2. HPDT

The CASS system in its present configuration cannot test Units Under Test (UUTs) above a specific power threshold. The High Power Device Tester (HPDT) will be an addition to the CASS system designed for testing UUT's with power requirements that exceed the current power threshold, specifically radar systems. The Navy intends to buy support equipment to replace equipment currently used to support the APG-65, ALQ-99, APS-137, and AWG-9 radar systems. The acquisition will consist of Operational Test Program Sets (OTPS) for CASS, the required ancillary equipment (HPDT's), and the associated Integrated Logistics Support (ILS) needed to augment the Radio Frequency (RF) configuration of CASS. The equipment acquired under this solicitation must test the full operational capability of the avionics of the selected radar systems and isolate faults. The required ancillary equipment must also provide the high

power augmentation necessary for testing other systems, present and future, such as the APG-73 radar. [REF. 2]

B. THESIS OBJECTIVES AND RESEARCH

The purpose of this thesis is to perform a case analysis of the proposed HPDT acquisition and develop an independent cost model for the HPDT program. The primary research question is:

What are the cost and benefit assumptions, are they all valid for this system, and are all feasible costs and benefits accounted for?

Relevant subsidiary questions are:

> Do additions to the CASS system increase the queue for individual components due to one station serving many different components one UUT at a time?
>
> As the capability of CASS is increased is the funding sufficient to increase the number of stations required to meet current and offload requirements?

C. METHODOLOGY

Research began with a review of official Navy reports and documents relating to two areas. First the background and fleet implementation plans of the CASS system were examined

with emphasis on costs, benefits, and funding plans. Second, the proposed introduction of HPDT was looked at, with emphasis on the cost benefit analysis assumptions and the future budget outlook.

The author also attended the HPDT pre-solicitation conference and visited the Test Integration Facility (TIF) in Virginia Beach, Va.

Finally, personal and telephone interviews were conducted with representatives of the CASS program office and the HPDT introduction team.

D. THESIS CHAPTER SUMMARY

Chapter II is a CASS overview. It begins with a description of the CASS system. It then traces the progress of the current CASS implementation, and ends with the latest projected plans for the CASS implementation. Chapter III is the HPDT program overview, it begins with the objectives and proposed schedule and fleet introduction. It then describes the configurations of the HPDT equipped CASS stations, and ends with the proposed acquisition plan. Chapter IV is the HPDT cost model the author developed. It begins with the criteria selected and the assumptions made. It then describes the model and its outcome. Chapter V is the existing ATE life cycle cost model. It begins with the criteria specific to the ATE model and the model assumptions. It then describes the

costing in the model and its outcome. Chapter VI is a comparative analysis of HPDT to existing ATE. It begins with the criteria selected and the assumptions made. It then presents the evaluation of the HPDT program against existing ATE. Finally, Chapter VII presents a summary of the research, conclusions and recommendations.

II. CASS OVERVIEW

This chapter will provide a quick overview of CASS. It describes the concept and expected benefits behind CASS and provides an awareness of where the program is now as well as where it is going.

A. CASS SYSTEM

The CASS concept was developed by NAVAIR as the next generation of ATE for support of aircraft electronic systems on board aircraft carriers and at shore sites. NAVAIR initiated the program in response to increasing concern about ATE problems, including, the proliferation of different ATE systems that was occurring in the 1970's and 1980's, and costly technology insertion and isolated ATE procurement. CASS is a new ATE system that is intended to incrementally replace existing ATE systems used at I-Level and D-Level maintenance activities. Benefits of CASS include:

- Improved throughput capability
- Improved ATE reliability and maintainability
- Increased expansion capability
- Reduced Life Cycle Costs over existing ATE

- Reduced acquisition costs for new weapon systems by eliminating the need for/or acceptability of new peculiar support equipment

CASS is a modular, reconfigurable, computer driven automatic test station that provides performance verification and fault isolation for complex electronic components. It has four configurations: hybrid core, electro optical, communications/navigation/identification, and radar. [Ref. 3] This thesis will look at the HPDT enhancement of the radar configuration.

B. CASS HISTORY

The CASS project began in 1978 in response to the NAVAIR ATE Program Plan to provide a long term solution to ATE proliferation and logistics concerns. It has two objectives: first, to improve readiness and operational availability through reduced repair cycle time; second, to decrease the logistics support cost of ATE through standardization of hardware and software.

CASS is an acquisition category (ACAT) II. ACAT I is the highest level and is generally assigned to programs that have costs exceeding $1 billion. The high acquisition category is due to SECNAV interest and relatively high cost. [REF. 3] The CASS program is right on schedule and has just passed its milestone III decision approving the lot IV full rate

production contract. [REF.4] Currently 90 CASS stations have been delivered to the Navy and a planned rate of two per week is expected from April 1994 through June 1995. Although lot IV production has been approved the lot V production is still dependant on further analysis of whether another open competition is to be held or the contract is sole sourced to the present contractor. Presently the end inventory of CASS stations is expected to be 720.

General Electric was awarded the engineering and manufacturing development contract for CASS, and was required to qualify a dual manufacturing source under a subcontract arrangement. The dual manufacturing source to be qualified was Martin-Marietta. After Martin-Marietta was qualified as an acceptable manufacturing source, the second Low Rate Initial Production (LRIP) contract was awarded in July 1992 to GE/Martin-Marietta as a 60/40 split. In April 1993 Martin-Marietta and GE merged, effectively eliminating the second manufacturing source. The third LRIP contract and the full rate production lot IV contract were awarded sole source to Martin-Marietta [REF. 5].

C. CASS OFFLOAD

"Offload to CASS" is the term the Navy is using to describe the disposition of ATE systems that are being replaced by the CASS stations. Simply put there isn't a

necessity to maintain two systems that do the same job, or enough room on Naval ships to add more support equipment. As CASS stations are installed and brought on line, the existing replaced ATE must be offloaded and the system support shifted to CASS.

D. CASS FUTURE PLANS

The future of the CASS program is still expected to remain on schedule, as shown in Figure 1 [REF. 4], but there are a few unresolved issues. It is still undetermined at this point whether the remaining production lots will be contracted on a sole source basis with Martin-Marietta or reopened for full and open competition again. Another issue that may affect future production of CASS stations is a down sized configuration tester for the Marine Corps. This tester would be configured for use on "L" class ships, and would result in the elimination of testers offloaded to CASS that smaller ships may still have to maintain because there isn't a CASS station available to them. [REF. 6]

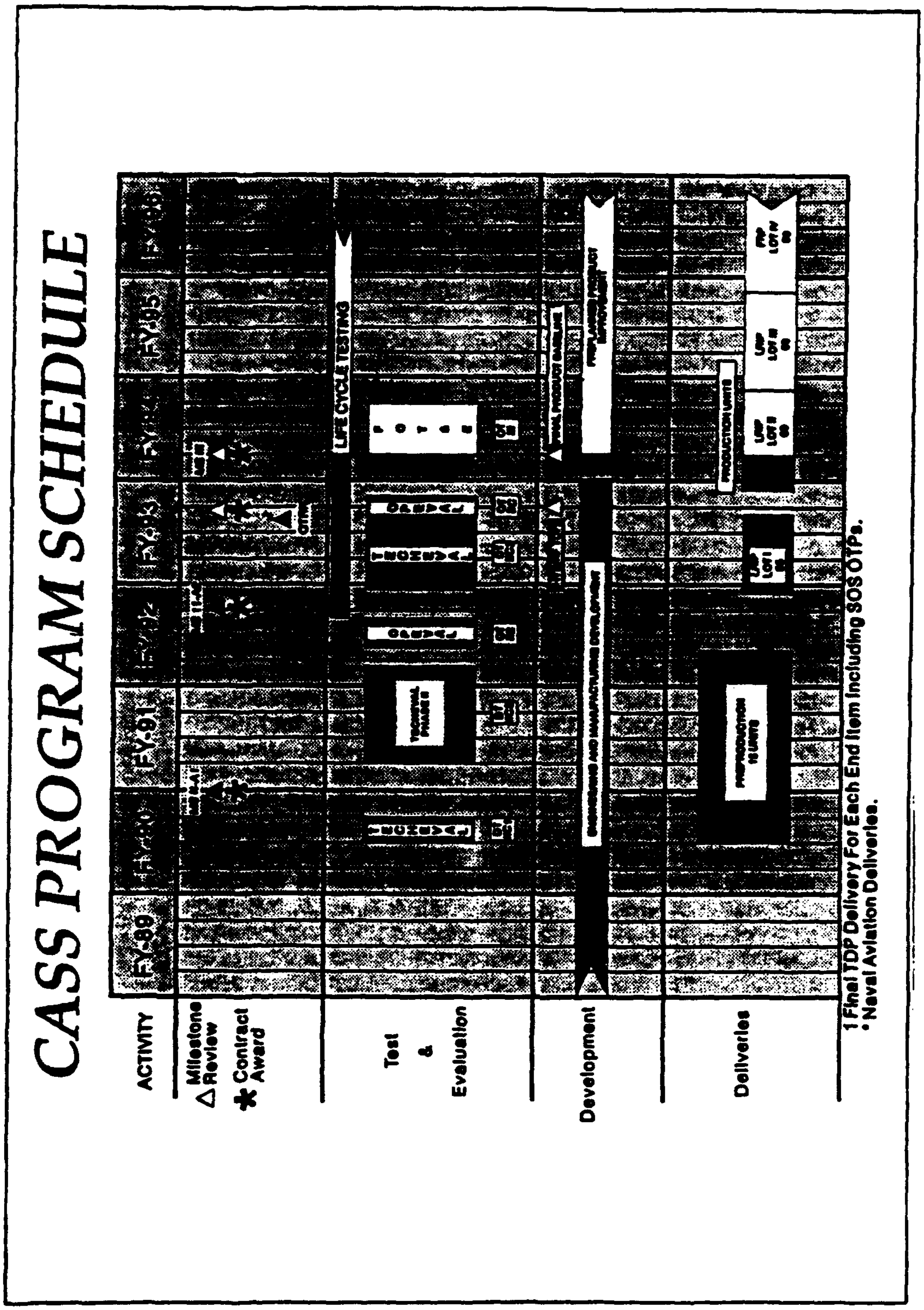

FIGURE 1. CASS Program Schedule

III HPDT PROGRAM

A. DEFINITION OF HIGH POWER DEVICE

A High Power Device (HPD) is generally one that meets or exceeds one or more of the parameters contained in Table I. However, as requirements have evolved for determining what Weapon Replaceable Assemblies (WRAs) and Shop Replaceable Assemblies (SRAs) will be tested on CASS RF/HPDTS, by default, an HPD has been further identified as a WRA or SRA whose system will be maintained by CASS, and contains one or more WRAs/SRAs not testable by one of the "normal" CASS configurations. [REF. 8]

TABLE I. HIGH POWER CRITERIA

PARAMETER	VALUE/RANGE	PARAMETER	VALUE/RANGE
Prime Power	> 5 kVA	DC Power	> 32V @ 100 A > 100V @ 8 A > 450V @ 2 A
D C Load	> 500 Watts		
RF Output	> 500 Watts Average > 5 kW Peak	Variable 0-135 Vrms, 400 Hz, 3 Phase	> 4.5A
Liquid Cooling	All	115 Vac, 400 Hz, 3 Phase	> 30A

B. OBJECTIVES

The objectives of the HPDT program are to enhance the capabilities of the CASS system allowing CASS to test devices that currently exceed the power threshold, to increase the throughput of UUTs requiring more power than is currently available with CASS, to increase the "standardization " of the

support equipment, and to reduce the long term logistics costs that are expected with the current family of HPD ATE.

C. HPDT OVERVIEW

The HPDT program started in May of 1991 with the "HIGH POWER TRANSMITTER PROGRAM ELEMENT STUDY" completed by the Pacific Missile Test Center. This study showed that CASS was the best candidate because it met most of the test requirements and would be more economical to modify or augment, and operate. In late 1992, NAVAIRSYSCOM officially decided that an augmented CASS Radio Frequency (RF) test set would become the test set to test not only HPTs, but other high power devices also. [REF. 8] In May of 1993 the Institute for Defense Analysis, CASS Pre-Planned Product Improvement Study, corroborated the need for a High Power Device Test Subsystem (HPDTS). By July of 1993 the Commander, Naval Air Systems Command (PMA-260) approved the decision to go full and open competition to offload high power UUTs for the APG-65, AWG-9, ALQ-99, and APS-137 radar systems.

High power ATE offload industry reviews were conducted in the second half of 1993 with a market survey synopsis in July of 1993 and 11 companies responding. In November of 1993 a high power specification was distributed with 54 companies responding and seven companies providing comments. A draft request for proposal was released to 45 companies in December

of 1993, and a Pre-Solicitation conference was held in February of 1994 with 134 contractor representatives in attendance. Finally, there are industry tours of Fleet Maintenance activities being scheduled as of March 1994. [REF. 9]

The current program scope consists of five radar systems as shown in Table II, but is expected to grow to encompass NAVSEA, SPAWAR, and possibly United States Army and Air Force requirements. As of March 1994 the Assistant Program Managers for Logistics for the AV-8B, F-14, S-3, P-3, and EA-6B programs have approved the HPDT program with the F/A-18 approval pending. [REF. 9]

TABLE II. CURRENT PROGRAM SCOPE

System	Aircraft	Current ATE
AN/APG-65	F/A-18, AV-8B	AN/APM-446 (RSTS)
AN/APS-137	S-3, P-3	AN/APM-457 (TTS)
AN/AWG-9	F-14	AN/AWM-23 (RFTS)
AN/ALQ-99	EA-6B	OJ-615/602 (TTS)
AN/APG-73*	F/A-18	CASS
* Only common high power requirements		

The benefits of the HPDT program include:

- A common approach that satisfies a requirement of Naval Aviation with a single investment.
- The common solution provides multiple channels to support the I-Level workload.
- A reconfigurable approach allows flexibility in matching capability with a changing demand and environment.

- Pre-planned product improvement provides upgradable features allowing for future growth.
- CASS with the HPDT ancillaries possesses the potential for increasing Joint Systems Command solutions and standardization throughout the DoD.

CASS is designed with an 80 percent parts compatibility among the different configurations. The high degree of compatibility should result in a reduction in inventories of repair parts necessary for support of the system.

D. HIGH POWER DEVICE TESTER DESCRIPTION

The HPDTS will provide additional alternating current (AC)/direct current (DC) power, and DC loads exceeding the CASS/RF test set capability. The HPDTS will be an external rack of test equipment which augments the capabilities of the CASS/RF test set. The HPDTS also includes RF loads, liquid cooling, and pressurization not featured in the CASS/RF test set. The HPD UUTs include transmitters, power supplies, and any UUT requiring DC loads. A power supply requiring high voltage DC power from one kilovolt to 20 kilovolts, or higher current DC power zero to 50 amps is considered a HPD UUT. HPD UUT support is also needed for transmitters requiring liquid cooling and RF loads. [REF. 9]

The HPDT system, as shown in Figure 2, will consist of a common high power ancillary core that will be standard for all HPDT uses and sets of individual ancillaries and OTPSs for

each of the UUT requirements. The individual hardware and software requirements will enable the HPDT stations to be tailored to the maintenance activity's needs.

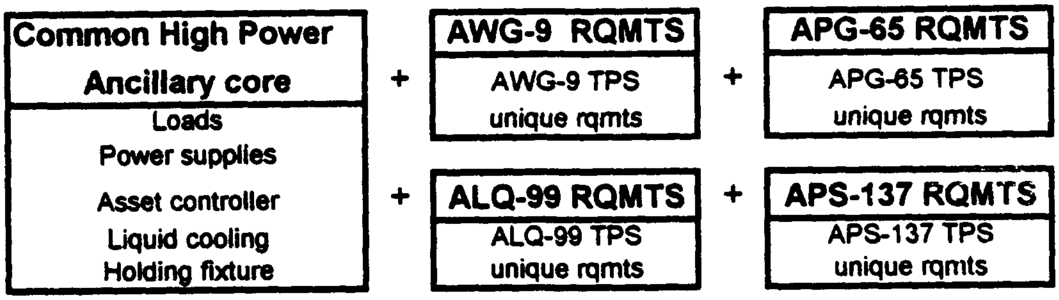

FIGURE 2. HPDT System Concept

E. EXISTING ATE OFFLOAD CANDIDATE DESCRIPTIONS

1. OJ-632/AWM-23 RFTS

The OJ-632/AWM-23 RFTS is one of five semi-automatic testers of the AN/AWM-23 suite of Support Equipment (SE). It provides semi-automatic test capabilities for performance verification and fault isolation of the F-14A, F-14A MOD, and the F-14A plus aircraft AN/AWG-9 weapons control system HPD UUTs. The OJ-632/AWM-23 covers 58.5 square feet of floor space and this offload will allow for the removal of the RFTS. A total of 25 of these testers were produced for the Navy by Hughes Aircraft Corporation. Initial Operating Capability (IOC) was reached in 1971, with an expected service life of 20

years. A Service Life Extension Program (SLEP) was performed on them in 1989. [REF. 10,11]

2. AN/APM-457 TTS

The AN/APM-373 TTS was originally procured as an interim manual tester to provide Intermediate Level (I-Level) test capabilities for performance verification and fault isolation of the S-3A AN/APS-116 radar system HPD transmitter WRA. A total of twenty systems were produced for the Navy by Texas Instruments. This tester covers 18 square feet of floor space. The AN/APM-373 TTS system was modified in 1985 to the AN/APM-457 TTS to provide I-Level maintenance support capabilities for the ES-3A and S-3B AN/APS-137 radar system HPD transmitter WRA. The equipment specification for the AN/APM-457 has been disapproved by the Navy because a lack of parametric data, therefore, no Integrated Logistics Support (ILS) documents exist for this tester. The expected service life of this tester is 20 years. [REF. 10,11]

3. AN/APM-446 RSTS

The AN/APM-446 RSTS is a programmable computer controlled test set which provides automatic test capabilities for performance verification and fault isolation of the F/A-18A/B/C/D AN/APG-65 radar system WRAs and SRAs. This tester covers 32.6 square feet of floor space. A total of 69 of the

systems have been produced, 61 for the Navy and eight for foreign military sales , for the Navy/Marine Corps by Emerson. IOC was reached in 1986 with an expected service life of 20 years. [REF. 10,11]

4. OJ-615A/ALM TTS

The OJ-615A/ALM TTS is an I-Level and Depot Level (D-Level) maintenance programmable computer controlled test set. It provides automatic test capabilities for performance verification and fault isolation of the EA-6B AN/ALQ-99 Electronic Warfare (EW) Countermeasures Set WRAs to the SRA level. This tester covers 42.9 square feet of floor space. A total of 27 sets have been produced for the Navy/Marine Corps by Grumman Aerospace Corporation. IOC was reached in 1986, with an expected service life of 20 years. A component repair program was performed on the sets in 1990.[REF. 10,11]

F. UNIT UNDER TEST DESCRIPTIONS

1. AWG-9 Avionics

The AWG-9 F-14 radar system has 12 WRAs and 54 SRAs/ Sub SRAs (SSRAs) tested on the RF variant of the AWM-23. 10 of the WRAs and 19 of the SRAs will have new TPSs created for CASS through Test Program Set Development (TPSD). Two WRAs

not tested on the RFTS will have TPSs developed due to their attributes which meet the criteria of HPDs. This system has been selected based on a Level Of Repair Analysis (LORA) Using data from the Navy's 3M system, input from the ATE Cognizant Field Activity (CFA), and recommendations from the F-14 Assistant Program Manager for Logistics (APML). [REF. 8]

2. APS-137 Avionics

The APS-137 S-3/P-3 radar system is using the transmitter from the APS-116 system. This UUT is tested on the APM-457. This WRA is the only UUT considered for offload within this segment of the HPD Offload effort. The WRA has five SRAs and 16 SSRAs, but none of the SRAs or SSRAs are in the offload candidate catagory. The SRAs were dropped due to testability on other ATE or the SRAs are fluid filled sealed units beyond the repair capability of the I-Level. This selection was based on the LORA, input from the ATE CFA and recommendations from the S-3 and P-3 APMLs. [REF. 8]

3. APG-65 Avionics

The APG-65 F-18/AV-8B radar system is tested on the AN/APM-446 (RSTS). The items selected for offload in the HPDO effort were previously included as lot II of the RSTS offload. This lot consists of two WRAs and seven SRAs. This selection

was based on the LORA, input from the ATE CFA, and recommendations from the AV-8B APML. [REF. 8]

4. ALQ-99 Avionics

The ALQ-99 EA-6B countermeasures set has seven WRAs and no SRAs as tested on the OJ-615. All of the WRAs will have new TPSs created for CASS through TPSD. This selection is based on the LORA, input from the ATE CFA, and recommendations from the EA-6B APML. [REF. 8]

5. New Development

All items identified as new development UUTs will have CASS OTPSs developed as a separate effort from the HPDO. The AN/ALQ-99 currently has two transmitters under development. These UUTs should be considered as future Test Program Set (TPS) development candidates. No other new development UUTs have been identified within the other three avionics systems under consideration. Table III is a list of other possible future HPDT offload candidates.

TABLE III. POSSIBLE FUTURE OFFLOAD CANDIDATE

USM-458C/USM-392B	EA-6B Digital Test Bench
AWM-23 Low Frequency Test Set	EA-6B Exciter Test Bench
AWM-23 Modular Test Set	CAT IIID
AWM-23 Computer Test Set	USM-470(V)2 TMV
AWM-23 Display Test Set	AQM-24B

G. ACQUISITION STRATEGY

The acquisition strategy for the HPDT program is a full and open competition with a cost plus incentive fee contract for the developmental phase and Firm Fixed Price (FFP) contracts for the rest of the acquisition. The Navy is also making the HPDT a "best value" contract. Best value meaning that the proposals will be evaluated for how they meet all of the program objectives and requirements, as well as the capability of the contractor to meet those requirements. [REF. 2] This approach should reduce the opportunity for under bidding and possible collusion by contractors since it will award the contract to the contractor that displays the best deal for the government.

The planned acquisition schedule or contract structure consists of a basic contract in FY-95 for eight High Power Ancillaries and two Operational Test Program Sets (OTPS)for each system supported. The first option will be in FY-96 for additional follow-on OTPSs for the ALQ-99 and AWG-9 systems. The Second option is planned to occur in FY-98 with production of 30 High Power Ancillaries and additional OTPSs for all of the supported systems. Option III of the contract is scheduled for FY-99 and production of 40 more High Power Ancillaries. The last of the ancillary equipment is scheduled to be in option IV of the contract with 30 more units acquired

for the United States Navy and a few for foreign military sales in FY-2000. The final two contract options are specifically for foreign military sales.

IV LIFE CYCLE COSTS OF HPDT

The HPDT cost analysis considers a number of quantifiable criteria and basic assumptions about those criteria in determining cost structures. These costs are then calculated for the expected life of the program in 1994 dollars. An inflation adjustment is calculated into the annual totals and a Net Present Value (NPV) is determined using a discount rate provided for U.S. government investments. The NPV is the expected outlay of funds required if the entire program were to be funded in its entirety at the present time.

A. CRITERIA

The criteria used to develop the Life Cycle costs of the HPDT are estimates since this system is now being developed and historical data are not fully applicable to this system. The estimates and expected outcomes have been gathered from official and preliminary government documents. This cost analysis will concentrate on the planned changes in costs associated with implementing HPDT, thus, eliminating consideration of those factors that are not expected to change or significantly affect the outcome. These criteria include:

- Hardware acquisition costs

- Software acquisition costs
- System developmental costs
- Training costs
- Installation costs
- Maintenance costs
- Manpower costs
- Offload of existing ATE costs
- Management costs

These criteria are not fully encompassing of all associated costs with the HPDT acquisition but, are a compilation of the latest estimates at this time.

B. ASSUMPTIONS

These assumptions are based on government documents, opinions and assessments of HPDT introduction team members and the author:

- All cost estimates in this study are in 1994 dollars.
- The CASS RF/HPDT system operational support period will be from 1994 through 2018.
- Each CASS OTPS will require one CASS test set except the eight units to be used in the Test Integration Facilities which already have CASS stations.
- Test Program Set and ancillary equipment development costs will be spread over four years prior to initial operating capability.

- CASS RF/HPDT initial operator training will require one person from each of the activated sites to be trained for each HPDT system that the activity will receive.

- 1.3 HPDT operators are required for each HPDT system at an activity.

- Manpower costs are based on $30,000 per operator/maintainer

- The first 40 HPDT installation will be completed by contractor personnel with Naval Aviation Depot (NADEP) personnel in attendance. All other installations will be accomplished by the NADEP personnel.

C. MODEL

The model is imbedded in a spreadsheet of cost factors taking into account all of the current cost assumptions as of the date of this thesis. It is compiled on a 24 year time line with all values in 1994 dollars. The net present value reflects a 3.19 percent constant inflation rate and a 4.5 percent discount rate in accordance with memoranda from the acting Deputy for Cost Analysis regarding economic analyses for projects with investment profiles in excess of ten years [REF. 12]. The cost explanations and usage are as follows:

TABLE IV. ACQUISITION COSTS

CASS cost each	$	1,131,000.00
HPDT cost each	$	900,000.00
Contractor installation cost	$	15,000.00
Nadep installation cost	$	10,000.00

1. Acquisition Costs

Table IV shows the expected acquisition costs per unit. These costs will be allocated annually by multiplying the number of units scheduled to be delivered in a specific year by the cost per unit for both the CASS and the HPDT equipment and the installation cost. The first 40 units are allocated the contractor installation cost with the remaining units allocated the NADEP installation cost.

a. *CASS Stations Required*

One CASS station is required for each HPDT system. The cost of the CASS stations required is based on the PMA-260 estimated cost per unit of $1,131,000 for the RF configuration, multiplied by the number of units needed to perform high power device testing throughout the Navy. These costs will be added to the cost model on an annual basis as determined by the expected production/delivery schedule of HPDT units. Annualized CASS acquisition costs are calculated by multiplying the number of CASS stations delivered in a specific year by the unit cost. The delivery schedule is based on estimates from the high power test sub-system field activity team leader. Effectively the delivery schedule provides eight units in the first quarter of 1998, production of 21 more HPDT's in 1999, 40 in FY 2000 and the last 39 in 2001. The final result is delivery of 108 HPDT units.

b. *Ancillary Equipment*

The HPDT ancillary equipment costs are based on the current PMA-260 estimates of $900,000 per unit, and will be allocated on an annual basis in accordance with the proposed production schedule. Annual ancillary costs are calculated by multiplying the number of stations delivered in a specific year by the HPDT unit cost.

c. *Operational Test Program Sets*

The cost of the OTPSs is based on the estimated cost of developing the computer software. These costs are currently estimated to be $40 million and are covered in this analysis in the developmental costs section. Once these OTPS's are developed they are the property of the United States Government and do not require any royalties, or site licenses, thus no further costs are expected unless the UUT's are changed or upgraded. Currently there are no plans to modify the UUT's.

d. *Installation Costs*

Installation costs are based on the PMA-260 estimated costs of contractor installations of the first 40 units and will include additional costs of having NADEP personnel observing and learning the installation procedures. The estimated cost of contractor installations is $15,000

each. After the initial contractor installations are completed the installation costs will be based strictly on NADEP personnel installing the remaining units at an expected cost of $10,000 each. The annual installation cost is calculated by multiplying the number of stations delivered in a specific year by the contractor installation rate for the first 40 units and the NADEP installation rate for the remaining units.

TABLE V. DEVELOPMENT COSTS

Engineering	$39,000,000.00
Tech Data	$ 290,850.00
OTPS Development	$40,000,000.00
Total Development Costs	$79,290,850.00

2. HPDT Development Costs

The PMA-260 estimates of high power development costs are shown in Table V. Ancillary and OTPS development costs are estimated to be $39 million and $40 million [REF. 13] respectively and are to be spread out over a four year period prior to Initial Operating Capability (IOC). The percentage of the total development costs is divided into 25%, 50%, 15% and 10% to be allocated to the four respective years beginning in 1995.

Technical data development costs are expected to be $290,850 and will be allocated on the same basis as the ancillary equipment and OTPS development costs.

The annual development costs are calculated by multiplying the total development costs by 25% for 1995, 50% for 1996, 15% for 1997, and 10% for 1998. Thus achieving 100% cost allocation.

TABLE VI. START UP COSTS

Production start	$ 250,000.00
Tooling	$ 350,000.00
Pre-Production Engineering	$ 2,310,000.00
Total Start Up Costs	$ 2,910,000.00

3. Start Up Costs

Start up costs, as shown in Table VI, are estimated by PMA-260 to be $2,910,000 made up of pre-production engineering costs of $2,310,000, tooling costs of $350,000 and production start up costs of $250,000. [REF. 9] All of these costs will be allocated in FY 1997, the year prior to the first scheduled deliveries.

4. Training Costs

Training costs are shown in Table VII. The formula for calculating and allocating annual training costs is the

addition of the initial training costs and the recurring costs. Initial training costs are calculated by the multiplying the number of stations installed in a specific year by the total initial training cost per student multiplied by 1.3 students/operators per shift per station. The recurring training costs are determined by multiplying the attrition rate of the operators by the number of stations in use multiplied by 2.6 operators per station to get the number of trainees. The number of trainees required multiplied by the recurring training cost per student plus the annual instructor cost is then added to determine the annual allocated cost.

TABLE VII. TRAINING COSTS

Annual Instructor Cost	$	30,000.00
Recurring Training Costs/student	$	628.00
Nunber Of Students Annually	.33 of operators	
Initial Training Costs/Student		
Travel And Per Diem	$	1,800.00
80 Hours @$15	$	1,200.00
Total Initial Training Cost/Student	$	3,000.00

a. Initial Training

Initial training costs are based on the cost of sending 1.3 operators per shift times two shifts for initial training for each CASS RF/HPDT to be set up at each of the

activated sites. These costs include travel and per diem as well as the payroll costs of the students while attending 80 hours of school. The average travel cost to the training site is estimated to be $600 per student. Per diem is estimated to be $100 per day for 12 days at the training site per student. A standard labor rate of $15 per hour is applied to the 80 hours of class per student. [REF. 9] These costs will be allocated in the fiscal year that the sites are activated.

b. Recurring Training

Recurring training costs are based on the expected additional costs of keeping CASS HPDT students in school an extra week. HPDT training is expected to add only one week to the current CASS training at an average historical cost of $628 per student. The total number of annual CASS HPDT students will be based on a 33% fleet attrition rate of an expected 260 fleet operators required. The number of operators required is determined by 1.3 operators per shift times two shifts times 100 HPDT stations. The total annual recurring training costs include one instructor at a standard $30,000 per year rate and are expected to be $83,882.

5. Maintenance Costs

Table VIII shows the maintenance costs. Annual maintenance costs for both the CASS station and the HPDT

ancillaries are based on the expected per station annual operating hours of 3460. Operating hours are determined by multiplying seven operational hours per shift by two shifts per day by five days per week times 52 weeks per year. The PMA-260 estimates of Mean Time Between Failures (MTBF) is 359 hours for CASS and 600 hours for HPDT. The PMA-260 estimated average depot level repair costs per failure is $10,800. The cost per failure multiplied by the combined expected number of failures of both the HPDT and CASS hardware systems will provide the annual estimated maintenance costs. The average first year usage of the initial stations delivered is expected to be 75% as these stations are planned for the first quarter of 1998 for test and evaluation purposes. The remaining 100 production stations are expected to have an average usage of 50% in their first year as the deliveries of these units will be distributed uniformly throughout the year. The annual maintenance costs are determined by dividing the operating hours per station by the MTBF for the CASS station to get the expected number of failures per station. The number of failures is then multiplied by the number of stations in use to get the total number of failures. The total number of failures is then multiplied by the percentage of depot level repairs as estimated by PMA-260 and multiplied again by the depot repair cost to determine the total maintenance cost. This calculation is repeated for the HPDT ancillary equipment

and the costs are added together to obtain the annual allocated maintenance cost.

TABLE VIII. MAINTENANCE COSTS

Year	1998	1999	2000	2001	2002+
Operating hours/sta	3640	3640	3640	3640	3640
Current no. stations	0	8	26	57	108
Stations delivered	8	18	31	51	
Avg. use 1st yr.	0.75	0.5	0.5	0.5	0.5
Total no. of stations	6	17	41.5	82.5	108
% D-level repairables	0.59	0.59	0.59	0.59	0.59
Est avg repair cost	$ 10,800	$ 10,800	$ 10,800	$ 10,800	$ 10,800
CASS					
MTBF	359	359	359	359	359
No. of repairs	36	102	248	494	646
Annual repair cost	$387,645	$1,098,327	$2,681,210	$5,330,116	$ 6,977,606
HPDT					
MTBF	600	600	600	600	600
No. of repairs	21	61	149	295	387
Annual repair cost	$231,941	$ 657,166	$1,604,257	$3,189,186	$ 4,174,934
Total Annual Cost	$619,586	$1,755,493	$4,285,467	$8,519,302	$11,152,541

6. Manpower Costs

Manpower costs, as shown in Table IX, are based on the number of HPDTs in the fleet as determined by the site activation schedule. These costs are estimated by multiplying the number of operators needed per station (2.6) by the number

of stations in use and applying a standard man year rate of $30,000. The number of stations in use is determined multiplying the number of stations delivered that year by the usage rate and adding the number of stations delivered in previous years.

TABLE IX. MANPOWER COSTS

Year	1999	2000	2001	2002+
No. HPDT's in fleet	0	18	49	100
HPDT's delivered	18	31	51	
Avg use 1st yr	0.5	0.5	0.5	0.5
No. Billets	23.4	87.1	193.7	260
Manyear cost	$ 702,000	$ 2,613,000	$ 5,811,000	$ 7,800,000

7. Program Management Costs

Program management cost estimates were obtained from the HPDT implementation team leader and are shown in Table X. These costs are based on estimates from management activities tasked with specific functions required to implement the program. Program tasks are allocated to the specific offices designated to implement different parts of the program, these tasks are analyzed and man year estimates are developed. These man year estimates are used with a standard cost factor to come up with program management cost estimates. The specific data are business sensitive and are not accessible to the author. It is assumed the program management costs beyond

the full HPDT implementation period will be insignificant as the mission will be complete.

TABLE X. MANAGEMENT COSTS

YEAR	COSTS
1994	$ 960,000.00
1995	$ 2,280,000.00
1996	$ 1,900,000.00
1997	$ 2,730,000.00
1998	$ 1,430,000.00
1999	$ 1,280,000.00
2000	$ 1,230,000.00
2001+	$ -
Total Mgmt Costs	$ 11,810,000.00

8. Supply Support Costs

Supply support cost estimates are not available at this time but, due to the strong parts compatibility between all the different configurations of the CASS system, these costs are not expected to be significant.

9. Technical Data Updates

Technical data update cost estimates are not available at this time.

D. MODEL APPLICATION

Each of the cost elements were put into a spreadsheet and linked to the life cycle cost calculation model. The model summed the costs for each year to provide the total annual cost in 1994 dollars for each of the 24 years examined in this study. The model also multiplied the annual totals by the inflation rate to get the inflation adjusted total annual costs. Finally, the model calculated the net present value of the total life cycle costs applying the discount rate.

E. CONCLUSION

This study has produced a NPV Life Cycle Cost (LCC) estimate, as shown in Table XI, of $575,494,140 for the acquisition and operation of the HPDT addition to the CASS suite of ATE over a 24 year period. The LCC model does not contain inputs relating to the costs of removing and disposing of the existing ATE as these inputs are not available at this time. Currently NAVAIR has tasked NAWCADLKE code 35B2 with developing the existing offload plan and cost estimates.

This LCC analysis compares favorably to the current LCC estimates that have been developed for COMNAVAIRSYSCOM PMA-260. The preliminary, at this point, estimate being used by PMA-260 is $521 million. The difference in LCC's is attributable to the better access to information and the

requirement that as many costs as is possible be included in the PMA-260 estimate.

This analysis also highlights the significant growth in expected costs as the program continues to come closer to fruition. The High Power Device Support Study prepared by Naval Air Warfare Center Weapons Division, October 1993, resulted in a LCC of $139 million but for 65 HPDT's and it only covered a ten year period. [Ref. 3] The preliminary cost benefit analysis prepared jointly by Naval Aviation Depots Jacksonville, Fl., and Norfolk, Va., on 1 Mar 1994 resulted in a total cost of $228 million for the HPDT acquisition. [Ref. 4] The estimated costs of this program have greatly increased as more and more research and analysis is put into the development effort.

This relatively unsophisticated spreadsheet model of the LCC analysis is a good tool for managers to keep track of life cycle cost changes as new information is updated during the projects progression. An independent cost model can take the individual inputs from many different areas of expertise and produce an expected outcome that will change with additional inputs but, remain stable when comparing many different cost analyses.

TABLE XI. LIFE CYCLE COSTS

Year	1995	1996	1997	1998	1999	2000
Stations delivered	0	0	0	8	21	40
Stations installed				8	18	31
Total fleet operating stations				0	18	49
Developmental costs	$ 19,822,712.50	$ 39,645,425.00	$ 11,893,627.50	$ 7,929,085.00		
Program mgmt. costs	$ 960,000.00	$ 2,280,000.00	$ 1,900,000.00	$ 2,730,000.00	$ 1,430,000.00	$ 1,280,000.00
Production start up costs			$ 2,910,000.00			
CASS RF/HPDT cost				$ 7,200,000.00	$ 42,651,000.00	$ 81,240,000.00
Installation cost				$ 120,000.00	$ 270,000.00	$ 420,000.00
Training					$ 180,098.83	$ 298,202.38
Manpower costs					$ 702,000.00	$ 2,613,000.00
Maintenance costs				$ 619,585.59	$ 1,755,492.51	$ 4,285,467.01
Total Annual Cost	$ 20,782,712.50	$ 41,925,425.00	$ 16,703,627.50	$ 18,598,670.59	$ 46,988,591.34	$ 90,136,669.38
Inflation rate power	1	2	3	4	5	6
Inflation adjusted totals	$ 21,445,681.03	$ 44,642,930.85	$ 18,353,700.22	$ 21,087,852.36	$ 54,976,930.43	$ 108,824,625.49
Net Present Value	$ 575,494,140.04					

TABLE XI. LIFE CYCLE COSTS CONTINUED

Year	2001	2002	2003	2004	2005	2006
Stations delivered	39	0	0	0	0	0
Stations installed	51					
Total fleet operating stations	100	100	100	100	100	100
Developmental costs						
Program mgmt. costs	$ 1,230,000					
Production start up costs						
CASS RF/HPDT cost	$ 79,209,000					
Installation cost	$ 510,000					
Training	$ 481,682	$ 83,882	$ 83,882	$ 83,882	$ 83,882	$ 83,882
Manpower costs	$ 5,811,000	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000
Maintenance costs	$ 8,519,302	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541
Total Annual Cost	$ 95,760,984	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423
Inflation rate power	7	8	9	10	11	12
Inflation adjusted totals	$ 119,303,144	$ 24,472,946	$ 25,253,633	$ 26,059,224	$ 26,890,513	$ 27,748,320

TABLE XI. LIFE CYCLE COSTS CONTINUED

Year	2007	2008	2009	2010	2011	2012	2013
Stations delivered	0	0	0	0	0	0	0
Stations installed							
Total fleet operating stations	100	100	100	100	100	100	100
Developmental costs							
Program mgmt. costs							
Production start up costs							
CASS RF/HPDT cost							
Installation cost							
Training	$ 83,882	$ 83,882	$ 83,882	$ 83,882	$ 83,882	$ 83,882	$ 83,882
Manpower costs	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000
Maintenance costs	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541
Total Annual Cost	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423
Inflation rate power	13	14	15	16	17	18	19
Inflation adjusted totals	$ 28,633,492	$ 29,546,900	$ 30,489,446	$ 31,462,059	$ 32,465,699	$ 33,501,355	$ 34,570,048

TABLE XI. LIFE CYCLE COSTS CONTINUED

Year	2014	2015	2016	2017	2018
Stations delivered	0	0	0	0	0
Stations installed					
Total fleet operating stations	100	100	100	100	100
Developmental costs					
Program mgmt. costs					
Production start up costs					
CASS RF/HPDT cost					
Installation cost					
Training	$ 83,882	$ 83,882	$ 83,882	$ 83,882	$ 83,882
Manpower costs	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000	$ 7,800,000
Maintenance costs	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541	$ 11,152,541
Total Annual Cost	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423	$ 19,036,423
Inflation rate power	. 20	21	22	23	24
Inflation adjusted totals	$ 35,672,833	$ 36,810,796	$ 37,985,060	$ 39,196,784	$ 40,447,161

V. EXISTING ATE LIFE CYCLE COST

The existing ATE cost analysis uses the same costing methodology as the HPDT model. All of the cost input for this model comes from the HPDT presentation data provided by PMA-260.

A. CRITERIA

The criteria used in analyzing the life cycle costs of the existing ATE systems are based on historical costs and estimates of future upgrade and service life extension costs. These systems are fully developed and have accurate historical information available but, estimates of future support and rework costs still must be estimated for this analysis. These estimates are expected to have a much higher confidence than the HPDT estimates as they deal with planned extensions of the status quo.

This analysis will concentrate on the future costs of maintaining these systems and consider all past costs as sunk. The criteria considered include:

- System maintenance costs
- Manpower costs
- System Service Life Extension Program (SLEP)\ Commercial Test Equipment Replacement Program (CRP) costs
- Training costs

- Additional ATE/TPS required to support changes in force structure
- Capability enhancements required to augment capabilities or resolve logistics deficiencies
- ATE\TPS In Service Engineering (ISE)

B. ASSUMPTIONS

These assumptions are based on government documents, opinions and assessments of the HPDT introduction team members and the author:

- The service life of all the existing ATE will be extended to the year 2018
- SLEP/CRP will be performed on all existing ATE still in the system
- SLEP costs will be spread equally over a four year period
- CRP costs will be spread equally over a two year period
- The existing ATE SLEP/CRP non-recurring costs are assumed to be $1,000,000 based on Ref.4
- The existing ATE SLEP/CRP recurring costs are assumed to be 25% of the 1994 acquisition cost
- ATE SLEP/CRP do not affect the TPS's
- The supply support cost per year per tester for existing ATE is assumed to be $69,790, based on a historical mean average of the systems

These general assumptions are taken from the Cost Benefit Analysis prepared by the Jacksonville and Norfolk NADEPs. [REF. 7] Additional assumptions made by the author include:

- Recurring annual costs prior to HPDT implementation are irrelevant. These costs will be incurred whether HPDT is adopted or not
- The annual recurring costs of the Existing ATE systems will be considered from the year 2000 on. It is assumed the annual costs will start at 100% and fall to 0% during the implementation period, providing a mean average of 50% or only two of the four year implementation period
- SLEP and CRP will only extend the operational life of existing ATE by ten years

C. MODEL

This LCC model is imbedded in a spreadsheet designed to calculate the costs and recurring costs for the proposed offload ATE for the same time frame as the HPDT model. The input data are derived from historical data acquired and compiled for PMA-260. This model will encompass service life extension costs, capability enhancement costs, additional ATE/TPS costs, and annual training, maintenance and in service engineering costs.

1. Service Life Extension Costs

All of the existing ATE will require service life extension. The following SLEP costs are estimates PMA-260 obtained from the Cognizant Field Activities (CFA). The AWM-23 will require SLEP in the years 1999 and 2009 based on the last SLEP performed on these systems. These costs are expected to be $18,975,000 and $18,750,000 respectively. The APM-457 will require SLEP in 2005 and 2015 at costs of $31,590,000 and

$30,250,000 respectively. The APM-446 will require SLEP in 2000 and 2010 for the original 69 production systems and 2005 and 2015 for additional testers to be acquired in 1995. The SLEP costs for each system are estimated to be $272,050. The OJ-615 will require SLEP in 2000 and 2010 at costs of $18,662,500 and $17,381,250.

These costs are allocated with 25 percent in the year SLEP is due and 25 percent in each of the following three years to fully allocate the costs over the four year period as stated in the assumptions.

2. Capability Enhancements

Capability enhancements are required to either augment the capability or to resolve logistic problems resulting from obsolescence or UUT capability upgrades. Only two of the systems, the AWM-23 and the OJ-615, have current planned enhancements. The AWM-23 enhancements are expected to be completed during both SLEP periods at a cost of $7,196,439 and $3,342,630 respectively. The OJ-615 will also require enhancements during SLEP at a cost of $14,500,000 and $10,700,000 respectively. The OJ-615 also requires Integrated Logistic Support for expected deficiencies in 1996 and 2006 costing $5,150,000 and $1,850,000 respectively. These costs are estimates obtained from the CFAs by PMA-260 and allocated in the year that the SLEP is due.

3. Additional ATE\TPS's

Additional APM-446 ATE\TPS's will be required in order to meet the support needs of increased numbers of F/A-18's on board aircraft carriers not receiving the APG-73 radar and additional AV-8B aircraft that have the APG-65 radar. These acquisitions are planned for 1995 and costs are expected to total $45,486,820. These cost estimates were provided to PMA-260 by the CFAs and are allocated in the year of their planned acquisition.

4. Recurring Annual Costs

The recurring annual costs required to support the existing ATE are:

- Training costs, $1,442,332
- Maintenance costs, $7,696,195
- In service engineering, $5,332,376
- Manpower costs, $12,236,484

These costs are the summation of the historical costs of the individual training, maintenance, ISE, and manpower costs for each of the existing ATE systems considered in this model. These costs are allocated as recurring for each year from 2000 to 2018.

D. MODEL APPLICATION

Each of the cost elements were put into the spreadsheet and linked to the life cycle cost model. The model summed the data for each year to provide the total annual cost in 1994 dollars for the 24 years examined in this study. The model then multiplied the total annual cost by the expected inflation rate to get the inflation adjusted totals. Finally, the model calculated the net present value of the total life cycle cost applying the discount rate.

E. CONCLUSION

The net present value of the existing ATE cost analysis as produced by this model, shown in Table XII, is $719,804,968. This figure compares favorably with the cost estimates developed and used in the HPDT progress briefings.

This analysis also highlights the growth in cost estimates of maintaining the existing ATE. This figure has grown from the 01 March 1994 preliminary cost benefit analysis estimate of $604 million to a mid April program briefing estimate of $628 million to the current PMA-260 estimate of nearly $800 million.

TABLE XII. EXISTING ATE LIFE CYCLE COST

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003
SLEP/CRP costs									
OJ-632/AWM-23					$ 4,743,750	$ 4,743,750	$ 4,743,750	$ 4,743,750	
APM-457									
APM-446						$ 4,692,862	$ 4,692,862	$ 4,692,862	$ 4,692,862
OJ-615						$ 4,665,625	$ 4,665,625	$ 4,665,625	$ 4,665,625
Capability Enhancement									
OJ-632/AWM-23					$ 71,964,399				
APM-457									
APM-446									
OJ-615		$ 5,150,000				$ 14,500,000			
Additional ATE\TPSs									
OJ-632									
APM-457									
APM-446	$ 45,486,820								
OJ-615									
Annual Costs									
Training									
OJ-632/AWM-23						$ 193,424	$ 193,424	$ 193,424	$ 193,424
APM-457						$ 299,000	$ 299,000	$ 299,000	$ 299,000
APM-446						$ 827,285	$ 827,285	$ 827,285	$ 827,285
OJ-615						$ 122,083	$ 122,083	$ 122,083	$ 122,083
Maintenance									
OJ-632AWM-23						$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563
APM-457						$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000
APM-446						$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632
OJ-615						$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000
ISE									
OJ-632/AWM-23						$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430
APM-457						$ 422,640	$ 422,640	$ 422,640	$ 422,640
APM-446						$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306
OJ-615						$ 571,000	$ 571,000	$ 571,000	$ 571,000
Manpower									
OJ-632/AWM-23						$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820
APM-457						$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320
APM-446						$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924
OJ-615						$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420
Total costs	$ 45,486,820	$ 5,150,000	$ -	$ -	$ 76,708,149	$ 55,309,084	$ 40,809,084	$ 40,809,084	$ 36,065,334
Inflation power	1	2	3	4	5	6	7	8	9
Inflaton adjusted totals	$ 46,937,850	$ 5,483,811	$ -	$ -	$ 89,748,989	$ 66,776,268	$ 50,841,708	$ 52,463,559	$ 47,844,109
NPV	$719,804,968								

TABLE XII. EXISTING ATE LIFE CYCLE COST CONTINUED

YEAR	2004	2005	2006	2007	2008	2009	2010	2011
SLEP/CRP costs								
OJ-632/AWM-23						$ 4,687,500	$ 4,687,500	$ 4,687,500
APM-457		$ 7,897,500	$ 7,897,500	$ 7,897,500	$ 7,897,500			
APM-446		$ 1,292,237	$ 1,292,237	$ 1,292,237	$ 1,292,237		$ 4,692,862	$ 4,692,862
OJ-615							$ 4,345,312	$ 4,345,312
Capability Enhancement								
OJ-632/AWM-23							$ 3,342,630	
APM-457								
APM-446								
OJ-615			$ 1,850,000				$ 10,700,000	
Additional ATE\TPSs								
OJ-632								
APM-457								
APM-446								
OJ-615								
Annual Costs								
Training								
OJ-632/AWM-23	$ 193,424	$ 193,424	$ 193,424	$ 193,424	$ 193,424	$ 193,424	$ 193,424	$ 193,424
APM-457	$ 299,000	$ 299,000	$ 299,000	$ 299,000	$ 299,000	$ 299,000	$ 299,000	$ 299,000
APM-446	$ 827,285	$ 827,285	$ 827,285	$ 827,285	$ 827,285	$ 827,285	$ 827,285	$ 827,285
OJ-615	$ 122,083	$ 122,083	$ 122,083	$ 122,083	$ 122,083	$ 122,083	$ 122,083	$ 122,083
Maintenance								
OJ-632AWM-23	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563
APM-457	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000
APM-446	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632
OJ-615	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000
ISE								
OJ-632/AWM-23	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430
APM-457	$ 422,640	$ 422,640	$ 422,640	$ 422,640	$ 422,640	$ 422,640	$ 422,640	$ 422,640
APM-446	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306
OJ-615	$ 571,000	$ 571,000	$ 571,000	$ 571,000	$ 571,000	$ 571,000	$ 571,000	$ 571,000
Manpower								
OJ-632/AWM-23	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820
APM-457	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320
APM-446	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924
OJ-615	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420
Total costs	$ 26,706,847	$ 35,898,584	$ 37,748,584	$ 35,898,584	$ 35,898,584	$ 31,394,347	$ 54,475,151	$ 40,432,521
Inflation power	10	11	12	13	14	15	16	17
Inflaton adjusted totals	$ 36,559,373	$ 50,706,876	$ 55,021,067	$ 53,993,575	$ 55,715,970	$ 50,282,359	$ 90,032,693	$ 68,955,710

TABLE XII. EXISTING ATE LIFE CYCLE COST CONTINUED

YEAR	2012	2013	2014	2015	2016	2017	2018
SLEP/CRP costs							
OJ-632/AWM-23	$ 4,687,500						
APM-457				$ 7,897,500	$ 7,897,500	$ 7,897,500	$ 7,897,500
APM-446	$ 4,692,862	$ 4,692,862		$ 1,292,237	$ 1,292,237	$ 1,292,237	$ 1,292,237
OJ-615	$ 4,345,312	$ 4,345,312					
Capability Enhancement							
OJ-632/AWM-23							
APM-457							
APM-446							
OJ-615							
Additional ATE\TPSs							
OJ-632							
APM-457							
APM-446							
OJ-615							
Annual Costs							
Training							
OJ-632/AWM-23	$ 193,424	$ 193,424	$ 193,424	$ 193,424	$ 193,424	$ 193,424	$ 193,424
APM-457	$ 299,000	$ 299,000	$ 299,000	$ 299,000	$ 299,000	$ 299,000	$ 299,000
APM-446	$ 827,285	$ 827,285	$ 827,285	$ 827,285	$ 827,285	$ 827,285	$ 827,285
OJ-615	$ 122,083	$ 122,083	$ 122,083	$ 122,083	$ 122,083	$ 122,083	$ 122,083
Maintenance							
OJ-632AWM-23	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563	$ 3,051,563
APM-457	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000	$ 1,400,000
APM-446	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632	$ 2,081,632
OJ-615	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000	$ 1,163,000
ISE							
OJ-632/AWM-23	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430	$ 1,109,430
APM-457	$ 422,640	$ 422,640	$ 422,640	$ 422,640	$ 422,640	$ 422,640	$ 422,640
APM-446	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306	$ 3,229,306
OJ-615	$ 571,000	$ 571,000	$ 571,000	$ 571,000	$ 571,000	$ 571,000	$ 571,000
Manpower							
OJ-632/AWM-23	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820	$ 2,514,820
APM-457	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320	$ 3,331,320
APM-446	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924	$ 5,181,924
OJ-615	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420	$ 1,208,420
Total costs	$ 40,432,521	$ 35,745,021	$ 26,706,847	$ 35,896,584	$ 35,896,584	$ 35,896,584	$ 35,896,584
Inflation power	18	19	20	21	22	23	24
Inflaton adjusted totals	$ 71,155,397	$ 64,912,778	$ 50,046,633	$ 69,413,347	$ 71,627,632	$ 73,912,554	$ 76,270,364

VI. COMPARATIVE EVALUATION

This comparative evaluation of the life cycle costs will compare the net present values as well as the logistic advantages and disadvantages of both alternatives.

A. CRITERIA

The criteria this evaluation is based on, include:

- The NPV outcomes of each of the cost models
- The differences in annual funding outlays required for each alternative
- The cumulative annual funding outlays of the alternatives
- *The non-quantifiable costs and benefits of the* alternatives

B. EVALUATION

1. Net Present Value Of Costs

The net present values of both alternatives, as determined in this study, are much higher than the estimates that have been taken from official and unofficial documents. The NPV of the offload to CASS alternative is $575 million while the NPV of maintaining the existing ATE is $719 million. The difference in NPV's shows a savings of $144 million to the Navy if the offload to CASS is implemented. These net present

value costs show clearly that the CASS alternative is the best choice in the long run.

2. Annual Funding outlays

The annual funding outlays, as shown in Figure 3, provide quite a different look at the cost benefit analysis. The HPDT annual funding requirements start out higher than the existing ATE requirements due to the developmental costs that are necessary to start the program and the acquisition costs of the Ancillary equipment. In the first seven years of the analysis the CASS funding requirements exceed the existing ATE requirements in all but two years. In the eighth year and beyond the CASS funding requirements drop well below the existing ATE requirements and remain stable throughout the remaining life cycle.

The high initial costs have a strong effect on the NPV of the CASS alternative. If these initial acquisition costs could be spread out over a number of years there would be a substantial lowering of the NPV. The problem with this logic is that although the NPV could be lowered by spreading out the costs, the overall support costs would increase at a higher rate due to the required support of two systems instead of one. The initial costs must be expended in order to obtain a substantial benefit in the long run.

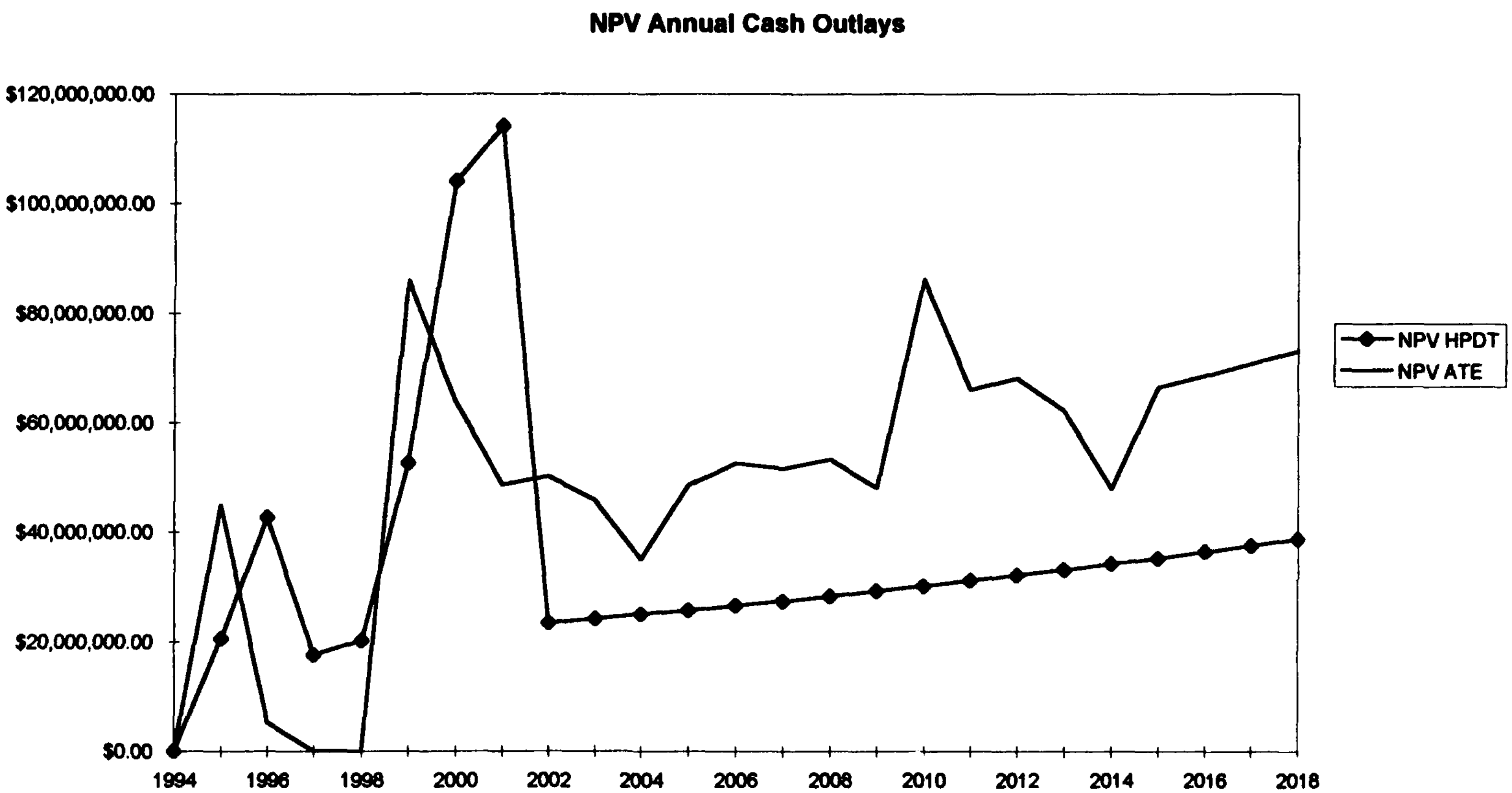

Figure 3. Annual Funding Outlays

The existing ATE funding profile shows three substantial spikes associated with the ATE service life extension programs necessary to keep the equipment in proper working order. If these costs were spread out further or the rework delayed there would be a substantial dampening of the NPV for the existing ATE alternative. This option is not viable, in that the rework costs are all ready assumed to be spread out over four years and spreading out the costs more is not practical. If the rework is delayed there will be a degradation in aviation support assets which will most probably result in a decrease in operational readiness of the fleet aviation assets. Adjusting the program alternatives to make annual funding requirements less dramatic in the near term will only result in program inefficiencies and higher costs in the long run.

3. Cumulative Funding Outlays

The cumulative funding outlays, as shown in Figure 4, show that the HPDT alternative will definitely cost more in the near term. This high initial cost is due to the acquisition costs of the ancillaries and software, but annual costs after completion of the inventory objective are much lower and very stable. The cumulative funding profile shows that from 1996 until the year 2006 HPDT costs will exceed

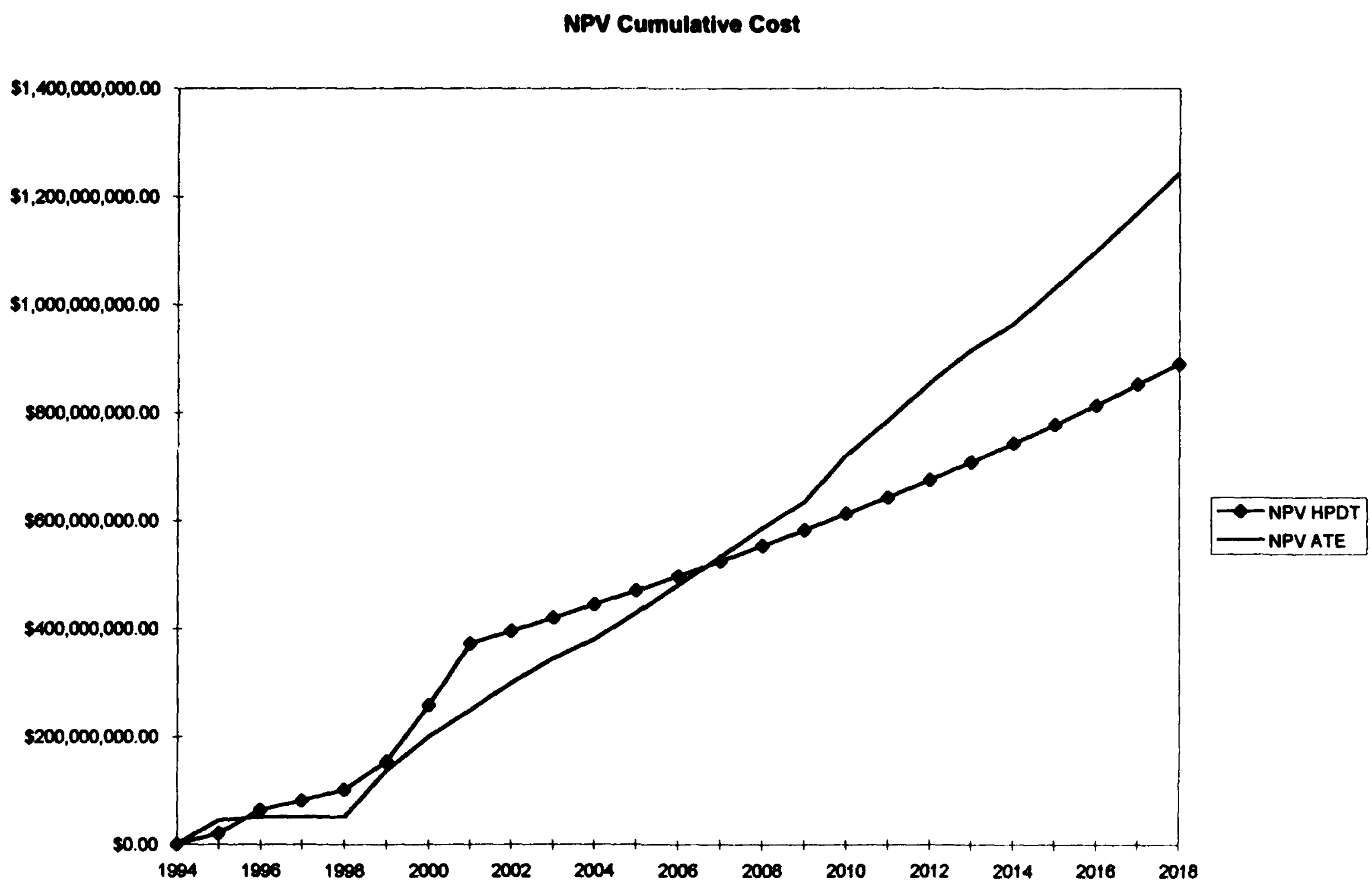

Figure 4. Cumulative Funding Outlays

those of the existing ATE. From 2007 to 2018 the cumulative costs of the existing ATE are greater than those of the HPDT program. The bottom line concerning cumulative funding is that the break even point is between the years 2006 and 2007. If the life cycle for the alternatives is less than ten years then the existing ATE should be more cost effective. If the life cycle is greater than 11 years than the HPDT program is more cost effective. Given that the proposed life cycle is 24 years long, the potential 13 benefit years and lower overall costs outweigh the initial ten higher cost years.

4. Non-quantifiable Costs and Benefits

Neither alternative can or should be based on funding costs alone, there are a great number of other factors that should be considered. Some of the potential benefits include:

- Future standardization of UUT design to the CASS concept
- A stepping stone to next generation technology
- Reconfigurable station design helps control backlogs
- Compatible with new avionics

Potential costs include:

- Next generation technology may render the CASS/HPDT obsolete prior to completion of its expected service life
- Production delivery risk

- Life cycle of avionics systems

These potential costs and benefits are not fully encompassing of all the factors that should be considered, but are just a representative few.

The increase in ATE standardization HPDT brings will cause future design and logistic costs to decrease. As CASS becomes the standard ATE system, design costs of future UUT's should be lower. Instead of developing new systems from scratch the systems will have a stepping stone of the CASS design to start from. This should decrease engineering development time resulting in lower overall costs. Standardization also makes reconfiguration of ATE assets possible allowing for optimal use of assets and elimination of costly backlog problems. Standardization reduces variability which ultimately makes planning more effective and reduces costs.

HPDT also uses the latest technology for a more efficient way of repairing UUT's. HPDT is not only compatible with the current suite of avionics in use but it also has pre-planned expansion capabilities. The current suite of ATE can accomplish the present need but, costly SLEPs and enhancements are required to keep up with the present direction of technology. Technology is not going to stop growing and the current suite of ATE is quickly becoming obsolete. Providing

the best tools for the expected tasks of the future is paramount in the HPDT alternative.

Next generation technology may also become a cost to the HPDT decision. Current avionics systems are sure to outlive the current suite of ATE, causing support problems. The offload candidates were originally procured with a 20 year expected service life. Except for the AWM-23, which passed its expected service life in 1991, all of the systems were designed to be in service for at least another ten years. The increased technology of avionics systems and HPDT not only make the offload candidates obsolete but, significantly decrease the benefit years of the previous suite of ATE. If future technology renders CASS/HPDT obsolete prior to its expected service life the life cycle cost calculations of today will be grossly understated.

Finally, the production risk of HPDT should not be discounted. The success of HPDT depends on timely production of deployable assets and an almost instant implementation allowing for the off loading of the current testers. If a production slip or implementation problems develop the Navy may be forced to support both the new and old systems resulting in a significant increase in costs.

C. CONCLUSION

Based on the results of this analysis the HPDT acquisition is the more cost effective alternative. Both life cycle cost analyses provided NPVs greater than the preliminary cost benefit analyses done by the professionals working for the CASS program manager but, the costs are still in line with updated estimates currently being used by PMA-260. The HPDT program will provide greater UUT support with an expected life cycle cost savings of $144,310,828 over the existing ATE.

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

The HPDT addition to CASS is nearing the request for proposals stage in the acquisition cycle. This thesis attempted to answer the question of whether this acquisition is cost beneficial or not.

To provide an answer to the research question, this thesis introduced the HPDT program and described its relation to the CASS program and the additional capability it will provide. It then summarized the CASS implementation program to show where the future of ATE is going. It next described the HPDT program, defining the power requirements, objectives, offload candidates and components to be tested. After laying the groundwork for HPDT, this thesis then develops the criteria and assumptions used to model the life cycle costs of the HPDT program as well as the existing ATE. Finally, this thesis provides a comparative evaluation of both life cycle costs including the annual cash outlays and the cumulative costs.

B. CONCLUSIONS

The primary conclusion of this analysis is that HPDT is cost beneficial and will save the Navy $144,310,828 over its

intended service life. As with any new system initial investment costs will be very high but once these costs are sunk the recurring operating costs associated with this system will remain relatively low and stable. The costs associated with the existing ATE that will be replaced by HPDT are expected to increase during the time frame of this study due to technical upgrades, service life extension programs, and replacement procurement.

Beginning in the year 2002 the annual cost of HPDT remains substantially lower than the annual cost of the existing ATE. These lower annual costs provide the HPDT program a break even point between the years 2006 and 2007 resulting in almost 12 years of overall program cost savings over the existing ATE for the remainder of the study period.

C. RECOMMENDATIONS

The following recommendations are made based on the above conclusions:

1. NAVAIR should continue the concept exploration and definition phase of development for HPDT and issue a request for proposals as soon as is practical. The demonstration and validation phase of the program should begin soon so as to not delay the initial operational capability and incur increased costs of maintaining and extending the service life costs of the existing ATE.

2. Continue in-depth cost analysis of the program as it develops. HPDT is still in the concept stage and close monitoring of expected costs will allow decision makers to

increase or decrease program emphasis as more accurate estimates are developed.

D. FOLLOW ON RESEARCH

This thesis modeled the current expected costs of the proposed HPDT acquisition; this is only part of the research that is needed to determine whether the acquisition is good for the Navy or not. Additional research is needed in the area of appropriate service life expectations for technologically advanced ATE. If technology advances make ATE systems obsolete prior to their service life completion then the benefit years of an acquisition are shortened. If the benefit years of a program are decreased, the acquisition may not be beneficial from a life cycle cost point of view. This could force the evaluation process to concentrate on technology advances and make costs less relevant.

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